National Estuarine Research Reserve System Science Collaborative
FY 2010 Funding Opportunity

Full Proposal Narrative

## 1. Coastal Management Problem and Approach

**Problem Definition and Current Approaches to Address the Problem.** Climate change impacts to the coastal communities surrounding the Kachemak Bay National Estuarine Research Reserve (KBNERR) involve complex interactions among several diverse processes such as: changes in sea level, shoreline erosion, sedimentation, water quality, glacial loss, isostatic rebound, and tectonic uplift or subsidence.

The KBNERR has been actively addressing some of these issues such as coastal erosion and changes in the terminal extent of glaciers in Kachemak Bay. Changes in the landscape have been documented through historical photographs and LiDAR (Light Detection and Ranging) elevation data (Baird and Pegau 2004, Baird 2009). However, the tools we have available to assess changes have limitations both temporally and in geographic scope and do not address large-scale changes in the landscape (geomorphic processes and glacier loss) and sea level rise. Measurements of vertical motions of survey marks around the Kenai Peninsula by the University of Alaska, Fairbanks have documented both significant uplift and subsidence of the land, in many cases at rates faster than the rate of global sea level rise (Fig. 1). The relative sea level fall predicted by the GPS observations agrees closely with the relative sea level fall documented in the long-term tide gauge record of the Seldovia tide gauge. However, elevation changes based on GPS observations in this region are not known well enough to meet the current needs of coastal managers. The KBNERR and public agencies (NOAA, State of Alaska, Kenai Peninsula Borough, City of Homer) have not had the resources to conduct broad-scale assessments of these issues.

To begin addressing concerns regarding the extent and rate of uplift, loss of coastal glaciers, and sea level change, KBNERR is proposing to document the rate of vertical change in the land surface at multiple locations around the Bay and to monitor biological changes resulting from sea level rise or fall, reduced glacial melt water, and coastal uplift. Information from these investigations will assist coastal managers in understanding habitat changes (identification of potential problems for bivalves, salmon, and wetlands) and coastal uplift may have implications for predicted rises in sea levels, patterns of coastal erosion, infrastructure construction and protection, and a whole host of planning, zoning and public safety issues in our communities.

This proposed work will be based on KBNERR salt marsh monitoring and the University of Alaska, Fairbanks (UAF) initial model of uplift for the Kenai Peninsula. We have a strong base but we need much better spatial information to address coastal management needs described above. With additional resources, we will create a detailed and precise model of uplift and change in the landscape, predict local sea level rise, and begin to document changes to the local ecosystem during the 3-year period.

**Coastal Management Problem.** The relationship between vertical landscape changes and sea level rise needs to be better understood in order to provide useful information to coastal decision makers on a variety of issues such as land use and community planning. Currently in the KBNERR, coastal uplift due to deformation from the great earthquake in 1964 and rapid ice-mass loss from immense ice fields have influenced our habitat and our coastal communities in many ways that have largely gone undocumented. A concurrent factor to the uplift of the landscape has been global sea level rise. Coastal communities rely on the near-shore habitat for transportation, safe harbor infrastructure, and food resources. In spring of 2009, fueled by recent articles from SE Alaska on isostatic rebound from melting glaciers and personal observations of changes in Kachemak Bay, community leaders approached the Reserve and asked for help to understand what is happening in our area. The proposed work will help fill in data gaps in the City of Homer's Climate Action Plan and contribute to fulfilling the Seldovia Village Tribe's mission statement. Specifically, the communities were interested in the implications for predicted rise in sea level, patterns of coastal erosion, infrastructure construction and protection, planning, zoning, and public safety issues. Changes in the local community ecology and potential impacts to food resources (salmon and their associated habitats and near-shore species of invertebrates and plants) were also identified as important.

**Addressing an RFP Focus Area.** We will be addressing the Habitat Change and Restoration focus area within the Science Collaborative RFP with a climate change emphasis. Having precise estimates of the vertical and horizontal movement of the landscape relative to sea level rise is relevant to coastal communities within the KBNERR. Changes in the landscape, such as uplift, inundation, erosion, all have impacts on the livelihoods of coastal communities (infrastructure, safety, and food resources). Providing good information to allow cities and boroughs to predict and prepare for change is essential. The research will provide an estimate of the variability in coastal uplift around the Bay based on underlying geomorphology and a greater understanding of surface sedimentation, erosion, compaction processes, and the net effect of these changes on important coastal ecosystems. Information from this study will refine other spatially explicit data (aerial photographs, LiDAR, and habitat maps) on relative changes currently available for coastal erosion, tide gauges, and near-shore habitat studies. We will also be poised to monitor uplift and sea level changes through systematic monitoring of vegetation in the salt marsh habitats and vertically controlled benchmarks. Changes in salt marsh habitat over time depend on relative sea level, which is the sea level relative to the land level, and because both surfaces are changing in this region, both need to be understood. Studies have shown that within the past decade, the loss of glacial ice mass has accelerated (VanLooy *et al.*2006, Larsen (http://gps.alaska.edu/chris) in south-central Alaska and input of sediment from melting glaciers is likely changing salt marsh elevations. Salt marsh vegetation can be a sensitive marker for elevation changes over time. In addition to being a sensitive indicator of elevation change, salt marsh vegetation may also be sensitive to the type of fresh water input. We will be able to assess potential differences in biological diversity among salt marsh habitats that are fed by glacial melt water and those marshes that are not. This will provide an index to potential biological changes as the glaciers recede. This research will also provide the foundation, data history, and equipment necessary to position KBNERR to continue monitoring uplift, sea

level rise, and changes in biological diversity associated with glacier loss and uplift in the estuary into the future.

**Physical and Social Context.** Kachemak Bay is located in southcentral Alaska (59.6º N and 151.5º W) and is designated as the Kachemak Bay National Estuarine Research Reserve and a State Critical Habitat Area (Fig. 2). The KBNERR is approximately 370,000 acres of estuarine, fjord habitat which is influenced by glacial input in the summer and by the marine waters of lower Cook Inlet and the Gulf of Alaska. The bathymetry is characterized by a submerged moraine at the mouth of the Bay and deep trenches and holes extending to depths of approximately 200-meters. A 6-kilometer spit extends south from the City of Homer to the center of the Bay and partially restricts water circulation. The south side of the Bay is generally deep with a rocky substrate, while the north side is shallow with soft sediment habitats. Seasonally, melt water from 15 glaciers flow into the KBNERR from the Grewingk/Yalik glacier complex and the Harding ice field. The sediments derived from these glaciers help build and sustain the predominantly sand and gravel beaches in the estuary. Changes in the volume and rate of fresh water and sediment input from the glaciers to Kachemak Bay and the corresponding effects on Kachemak Bay circulation patterns and the local ecosystem are not well understood. Nutrient rich water enters the Bay from the Gulf of Alaska and large tidal ranges (mean 5.5 meters, range 6.9 to -1.8m) contribute to the circulation pattern (Kachemak Bay Ecological Characterization 2001). The KBNERR is located within the Kenai Peninsula Borough (KPB) which was incorporated in 1964 as a second-class borough under the authority of the State of Alaska Borough Act of 1961. The Borough's governmental responsibilities are comparable to those of a county in other parts of the United States. The proposed research is important to this region as it is prone to active seismic and volcanic activity and coastal erosion. The KPB lies directly south of Anchorage, the State's principal population center and the waters of the Gulf of Alaska and Prince William Sound border the Borough to the south and east, respectively. Cook Inlet divides KPB into two land masses with the Kenai Peninsula encompassing 99 percent of the KPB's population and most of the development. The boundaries of the KPB encompass a total of 25,600 square miles, equal to that of Massachusetts and New Jersey combined, and 2,146 miles of coastline. On the 2.3 million acres of state land within the KPB, use varies from the intensely developed gas fields, timber sales, and proposed coal-mining projects, to developed recreation sites, protected game refuges and critical habitat areas, and wilderness parks. In communities surrounding KBNERR, traditional resource extraction industries (timber, fisheries, and agriculture) have been in decline, with a corresponding rise of tourism and real estate speculation. The Alaska Department of Labor Statistics data indicate a highly-seasonal employment pattern with nearly 50% higher employment in the summer months compared to the winter months. This seasonal infrastructure supports thousands of people who come to sightsee, fish, hike, and view nature.

## 2. Project Objectives

The over-arching project objective is to provide accurate vertical positioning information for coastal managers to support informed decisions on land use planning and public safety and improve predictions of future coastal elevation, sea level rise, and habitat

changes. The null hypothesis for this study is based on the pre-existing estimates of land surface uplift and relative sea level in the area and the estimated rate of global sea level rise: the uplift rate of the land in the Kachemak Bay region is uniform and equal to the regional average of GPS measurements, and uplift is faster than global sea level rise, with a net effect of producing a long-term decline in relative sea level. The impacts of sea level change on coastal ecology and on the local community have not been fully explored, or fully explained to the community, and we will do this as part of our project (see Methods and Timeline). The data collected through this project will allow us to test several additional hypotheses that relate to the causes and effects of sea level changes in Kachemak Bay. These hypotheses will be tested against the null hypothesis and used to develop a synthesis model that explains the causes of sea level change in the area and its effects on coastal ecosystems, while allowing more accurate predictions of future changes. We will involve and educate local and regional decision makers, local residents, and other potential Users of this information during and after the project. We will divide our project goals into several parts, each with associated hypotheses to be tested.

1. To determine if bedrock uplift rates in the area are uniform, or if they vary along the length of the Bay.
    - Hypothesis 1: Bedrock uplift rate is non-uniform, with slower uplift rates at the head of the Bay.
2. To determine if areas surrounding the coastline of Kachemak Bay that are largely comprised of unconsolidated glacial till are experiencing similar uplift projections to sites located on bedrock, and to monitor elevation and changes in vegetation in salt marshes as an indicator of the balance between sea level rise and coastal rebound.
    - Hypothesis 2: Soft sediments subside and compact, with the surface moving downwards relative to bedrock, and these locations experience less net uplift than bedrock sites.
    - Hypothesis 3: Increasing sedimentation and relative sea level fall are shifting salt marsh habitats seaward.
3. To improve earlier estimates of coastal uplift rates, which were generated for the greater Kenai Peninsula; refine models to better predict uplift rates in areas between measurement sites; refine estimates of regional sea level rise; and assess the impacts of coastal change for all coastal habitats of Kachemak Bay.
    - Hypothesis 4: Observed uplift rates can be explained by a model that combines isostatic adjustment due to melting of glaciers and icefields, steady tectonic deformation, and post-seismic deformation following the 1964 earthquake. Regional sea level rise can be explained by a combination of global sea level rise and changes in the shape of the mean sea surface related to the deglaciation of southern Alaska. If hypothesis 2 is confirmed, then compaction and subsidence of sediments would need to be added to the model for non-bedrock sites.
4. To identify the biotic diversity and community composition among salt marshes which are: ground and surface water fed, glacier melt water fed, and salt marsh habitat historically fed by glacier melt water but which is no longer fed by glaciers.

- Hypothesis 5: Biological diversity is influenced by the source of fresh water input to the salt marsh habitat.

5. To involve and educate local and regional coastal decision makers, local community residents, K-16 students, and other potential Users of the information during and after the study.
    - Hypothesis 6: Local decision makers (Core Intended Users, see Table 1) will be able to 1. communicate the benefits and goals of this study to others and 2. integrate and use the data generated from this study if they have opportunities to learn more about the basic geomorphic processes occurring in our region.
    - Hypothesis 7: By making our outreach and education available to the general public, we will identify additional Users of the information generated in this study

## 3. Intended Users and Anticipated Use

**Table 1. Core Intended Users and Anticipated Use**

| Core Intended Users (CIU) | Justification for listing this User | Organization & Professional Responsibilities | How the User may apply this information |
|---|---|---|---|
| City of Homer – Planning | Mayor requested information on coastal uplift & melting glaciers | Planning, zoning, and maintenance of city/port infrastructure | Predict potential problems and inform zoning and planning |
| City of Homer – Harbor | Water depth is critical to safe vessel traffic patterns | Maintenance and safety of the harbor users | Planning for harbor expansion and maintenance |
| Kenai Peninsula Borough | Land use changes including uplift and coastal erosion | Responsible for designating natural hazard areas | Identify potential problems and inform planning and zoning |
| Seldovia Village Tribe | Predicting changes to the local environment on tribal lands | Responsible for environmental monitoring of subsistence foods | Identify potential problems for subsistence harvest of bivalves/salmon |
| Alaska Department of Natural Resources – Division of Mining, Land and Water | Primary manager of the state's land holdings | Ensure state title, prepare land use plans, leases & permits on state land | Accretion/reliction due to isostatic uplift |
| NOAA/NOS/NCCOS-Kasitsna Bay Laboratory | Provides baseline information to KBL mission to understand climate change impacts on coastal ecosystems | Provide science products and tools to inform coastal management decisions | Support studies e.g. habitat impacts of glacial melt, habitat mapping, intertidal community biodiversity |

**Corroboration of Coastal Management Problem:** The existing framework for communication and information exchange brought our science collaborative question to the KBNERR table a year ago and has been followed up by KBNERR staff with a process for collaborative assessment design and action strategy. The KBNERR and local community members follow the Collaborative Learning principles, outlined by fellow Coastal Training Program (CTP) Coordinator Christine Feurt's Collaborative Learning Guide (Feurt 2008). The KBNERR was established with a strong local support in 1999 and has an established Community Council (2002) which provides a vital connection between Kachemak Bay communities, statewide and national research and education organizations, and the Research Reserve. Effective communication with all of these entities is critical to the Reserve's successful operation. The primary purpose of the Reserve Community Council is to provide an organized structure for substantive and meaningful dialogue and recommendations between agencies, local governments, researchers, environmental educators, conservation groups, and others interested in natural science research and education, and Research Reserve staff. Council meetings are held quarterly and are open to the public. The original question posed by the Homer Mayor in a short letter to the KBNERR manager, "..are we going to wash away or are we going to have acres of new shoreline," provides the basis for this community-based research question: What is happening to the landscape around Kachemak Bay with respect to climate change (loss of glacier mass, uplift, and sea level rise)? This question has been reiterated by informal conversations with locals who wonder why they see more shoreline at low tides and feedback from CTP Coastal Processes workshops.

To address this research question, the KBNERR responded in multiple ways such as:

- we brought the research question back to three quarterly Community Council meetings for discussion;
- through our CTP we facilitated, coordinated, and hosted multiple Climate Change Impacts & Adaptation events; we brought multiple local & regional experts together to share & present (separate events for each of the KBNERR Community Council, regional coastal decision-makers, and local residents);
- during the course of our outreach we had two scientific experts specifically address what is known about the science of rebound, sea level changes, and erosion rates within the Bay;
- we invited Core Intended Users (CIU) to meet and discuss the Science Collaborative RFP, they communicated a need for and would benefit from the information gained from the proposed study (see Table 1) and have committed to active participation throughout the study;
- we shared the letter of intent with CIU & asked for feedback; we engaged core Users of the data to write Letters of Commitment and to pass City of Homer and the Kenai Peninsula Borough Resolutions in support of the project (see Letters of Commitment) and an open process for CIU to review and comment on the draft proposal;
- our CIU have solicited and received a letter of support for this project from the Alaska Congressional Delegation (see Letters of Commitment).

**Anticipated Use:** Information from this study will allow regional coastal decision makers to use uplift projections to plan ahead in the development and maintenance of infrastructure (such as harbors), city planning, zoning, inform coastal erosion data, and identify coastal hazards. Information generated from this study will be directly applicable to the City of Homer's Climate Change Plan (2007) and provide a basis for understanding and predicting changes from uplift and glacier loss to the local ecology.

The research will provide an estimate of the variability in coastal uplift around the Bay based on underlying geomorphology and a greater understanding of surface sedimentation, erosion, compaction processes, and the net effect of these changes on important coastal ecosystems. We anticipate that the final report from this research will provide an updated elevation model with more precise estimates of coastal uplift in the Kachemak Bay area with a synthesis of uplift projections for the region. This research will also provide the foundation, data history, and equipment necessary to position KBNERR to continue monitoring uplift, sea level rise, and changes in biological diversity associated with glacier loss and uplift in the estuary into the future. Precise uplift rates acquired from this study will provide the additional benefit of keeping existing information/tools/models current such as digital elevation models developed from LiDAR and information for analyses of coastal erosion, inundation, and habitat change. This study will provide a basis for understanding the relative contribution of glacial melt water and sediment load to the biological diversity of this coastal estuary which is typical of south-central Alaska. The results from this study will be summarized in a report to the coastal decision makers which will be similar in style to the North Carolina Sea-Level Rise Assessment Report (2010). And finally, this study will provide outreach and education products such as CTP workshops for multiple coastal decision-maker User groups, data collection methods for Citizen Monitoring protocols, and education and outreach through *Discovery Labs* utilizing our state-of-the-art lab classroom within the Alaska Islands & Ocean Visitor Center. *Discovery Labs* provide KBNERR staff and partners a venue to outreach coastal science topics in an inquiry-based, hands-on learning environment. These labs center on themed activities where 8 or more learning stations are staffed by KBNERR and partner organization staff, and numerous volunteers. Annually, over 3,600 people of all ages participate in *Discovery Lab* activities.

## 4. Methods

### Data Collection and Analysis

*Hypotheses 1, 2, 4.* Each year of the study, we will make a series of precise GPS measurements using equipment procured through this grant to determine rates of coastal uplift in our study area (see Reference Map), using a mixture of new and pre-existing measurement sites (Fig 1). In addition to providing important data for the project, these sites will also provide precise survey control for work in marsh and other habitats. In year one we will deploy two continuous GPS monitoring sites (using Trimble Net-R5 or Net-R8 GPS receivers with Zephyr Geodetic or Zephyr GNSS antennas) near the head of Kachemak Bay. These sites will be located on or immediately adjacent to unconsolidated glacial till so that we can assess sediment vs. bedrock uplift rates. We will carry out repeat surveys of additional survey markers around Kachemak Bay including pre-existing bedrock sites (NGS geodetic and tidal benchmarks) and up to four new salt marsh sites.

New sites will be established following the NERRS protocols (Moore *et al.* 2009), with special attention paid to the vertical stability of the survey marks by anchoring them solidly at depth. In addition to the data from the continuous monitoring sites, all other GPS sites will be surveyed 2-3 times per year (each survey lasting a few days), with most of these surveys carried out by KBNERR personnel. Analysis of the GPS data will be carried out by Dr. Freymueller at UAF and will follow the methods outlined in Freymueller *et al*. (2008) for GPS data analysis and site velocity estimation.

A refined model of uplift rates will be determined, based on past data and the data collected in Objective 1, and will be used to predict uplift rates in areas between the GPS measurements sites. Prediction of uplift rates for areas with no direct observations can sometimes be done via interpolation, but more robust prediction results should be based on a numerical model of the causes of uplift. We will refine models for tectonic uplift in the region, and develop models for isostatic uplift caused by loss of glacier ice, based on the latest ice mass loss estimates. Modeling methods will follow those described in Larsen *et al.* (2005) and Freymueller *et al*. (2008). Regional sea surface changes can be estimated from average global sea level rise, and the change in the sea surface shape caused by loss of ice in the local area. This change in shape results from the small changes in gravity caused by removing mass from the local glaciers and icefields, and distributing that mass around the world's oceans, and it can be predicted from the same models that predict isostatic uplift. These estimates can be validated by comparing to independent data from satellite altimetry, and by combining these models with the observed GPS uplift rate and tide gauge data from Seldovia, Alaska. Relative sea level changes based on these observations combined with local tide gauge data will provide local estimates of relative sea level change for our region. The local estimates of relative sea level change will provide a context for interpreting biotic changes in coastal salt marshes.

*Hypotheses 2,3,5.* We plan to establish vertical control in four salt marshes and assess changes in vegetation as an indicator of sea level change. The proposed sites are: Beluga Slough (surface water/ground water fed), Fox River Flats Critical Habitat Area (primarily glacier melt water fed), China Poot Bay (glacial melt water fed until 1964), and Sadie Cove (cut off from glacial melt-water for >60yrs and possibly much longer). Of these sites, only Beluga Slough is accessible by road; all other sites are remote and are accessed by boat, float plane, or a combination of ATV and river boat (Fig.1). For all proposed study sites detailed vegetation classification and GIS maps of habitat types are available (which satisfies NERRS Tier I sampling protocol). To establish vertical control and monitor sedimentation rates, we will assess the availability of existing benchmarks in the National Spatial Reference System (NSRS). However, existing monuments are primarily associated with human infrastructure and we anticipate the need to set several new benchmarks to accomplish this task. Where possible, these will be the same benchmarks we will use to measure uplift rates. To detect changes in sedimentation accumulation rates, we propose to survey ground-surface elevations relative to permanent benchmarks at our sites (Jorgenson 2009). We will assess sediment accumulation in the spring and late fall at each site to assess seasonal variation. To assess salt marsh accretion and erosion we will monitor topography across a gradient from lower to upper marsh at each site and estimate percent cover of dominant plant coverage (Jorgenson 2009). Using

existing aerial photography and data collected in this study, we plan to update our NERRS salt marsh plant community maps for KBNERR and assess directional shifts in marsh vegetation relative to historical aerial-based photography.

Abiotic factors that will be continuously monitor throughout the study to assess physical characteristics of the salt marshes relative to plant and animal diversity at each site will include: temperature, salinity, and water level. To assess biotic diversity at our four selected sites we will randomly choose from among regularly-spaced transects (NERR System Wide Monitoring Plan bio-monitoring protocol, after Roman *et al.* 2001) and determine a sampling interval along each transect with a random selection of the start plot. Upper marsh and lower marsh are equivalent to high and low marsh in the NERRS habitat classification scheme (Kutcher 2008) and will be sampled in proportion to relative abundance of each habitat type at each of the four sites. Each study site will have the following instrumentation: two water level loggers (high and low marsh), one barometric logger (uplands immediately adjacent to the marsh), 12 soil temperature loggers (six high and six low marsh) and a minimum of three benchmarks. Each of the plots within a site will be sampled for percent cover of the dominant plant species in the fall of each study year. Vegetation sampling methods will follow the NERRS protocols (Moore *et al.* 2009, Roman *et al.* 2001, and Jorgenson 2009).

Each study site will be extensively sampled one time during the course of the study by trained community monitors and KBNERR staff (a maximum of 30 people). At each of four sites, project personnel and monitors will travel to the study area in a water taxi or landing craft (with the exception of Beluga Slough). Six randomly selected transects at the high and low marsh strata will be sampled for the following: infaunal invertebrates (core sampling), insects in the vegetation (sweeps and fallout traps), fish diversity and abundance (pole seines), bird diversity and relative abundance (point counts), mammal presence, diversity, and where meaningful, relative abundance (visual observation, tracks, and grazing). These methods are patterned after the National Geographic Bioblitz community monitoring program and will include participation by local Kenai Peninsula School District and Kenai Peninsula College – Kachemak Bay Campus students, and potential Users of the information.

*Hypotheses 6-7:* The KBNERR has multiple venues established for engaging local Users in coastal science efforts and outreach events that will be utilized for this study (see Users in Communication of Results section). For example, *Discovery Labs* are open to the public and offer educational opportunities for school-age children and adults. Each lab presents a topic of interest and takes place in our fully-equipped lab classroom. Topics are subdivided into eight different tables. Each table contains interesting factual information, and scientific investigations presented in multiple ways to appeal to a variety of ages and learning styles. Most tables include hands-on activities, and incorporate the use of dissecting scopes, close-up examination of live marine invertebrates, experiments that learners can conduct, and craft activities. *Discovery Labs* offered in the summer have a new topic each week, presented on Wednesdays, Fridays and Saturdays. These labs appeal to families and area visitors, with an average attendance of 120 people per day (360 per lab topic). Winter labs focus on one research topic per month. Winter *Discovery Labs* are open to the public on the first Wednesday of the

month and, with adjustments as needed to meet grade requirements, continue to be available for three weeks to accommodate K-16 students. Additional programming such as lectures, local news articles, and outdoor family programs build upon the topic of the month. Winter labs and associated activities attract families, home school groups, and inquisitive residents, with an average monthly attendance of 440 people. All programs are free to the public.

A quantitative and qualitative analysis of Users' increased understanding, integration, and use of study information will develop from the educational opportunities directly related to this study and outlined in the timeline (CTP Workshops on Coastal Processes and Lessons Learned and *Discovery Labs* on Coastal Processes, Influences of Glaciers on Ecology, and Earthquakes), follow-up evaluations (following the NERR CTP protocol & performance measurements), observations, and informal communications between KBNERR staff and Users throughout and after the study.

In order to assess the change in knowledge, awareness, use and integration of information on geomorphic processes and accurate vertical positioning data, an inquiry of understanding (front-end evaluation) will be delivered to the CIU at the first quarterly meeting (quarterly meetings will be held throughout the duration of the study – see Timeline) and a summative evaluation will be delivered at the completion of this project. These evaluations will measure change in the CIU understanding of coastal processes related to coastal decision-making. Our Integration Lead will make use of collaborative learning evaluation resources, materials, and processes and from existing literature such as that described by Walker, Senecah, and Daniels (2006) and Feurt (2008). The initial front-end evaluation process will also include an informal needs assessment during the first quarterly meeting to collectively identify stakeholder resources, activities, outputs, and outcomes. This initial needs assessment will be revisited throughout the study, modified when appropriate, and utilized for the final evaluation.

Throughout all phases of this study, identification of additional Users will be tracked through feedback from educational opportunities which include but are not limited to, CTP workshops, *Discovery Labs*, and Science Conferences. Additional Users will also be identified through email inquiries, informal communication with existent intended Users and KBNERR staff, and direct calls for participation through media outlets. Depending on the interests communicated by the additional Users, appropriate levels of project engagement and outreach will be determined to ensure adequate and relevant involvement of each User.

**Connecting Findings to Intended User Decisions:**
In the first quarterly meeting with Core Intended Users of the information, we will discuss existing models of coastal deformation and evaluate the interpretation and precision relative to the data we are about to collect for the region. We will compile all stated information needs and uses of the information identified in the Letters of Commitments and modify the list of intended uses based on our discussions. We will provide quarterly updates to Users as new information becomes available and share annual progress reports with CIU and the general public. A complete evaluation of the

significance of coastal uplift model findings (level of uncertainty, initial assumptions) will be reported on at the close of the study and include a discussion of the confidence level or margin of error for the reported ranges and rates of change for the Kachemak Bay area. At the close of the project, the investigators will recommend a useful rate or rates of uplift to be used for coastal planning purposes for this region and will recommend future monitoring to provide projection updates.

The monitoring of the salt marsh abiotic trends and biotic diversity will provide a descriptive evaluation of glacier-fed systems and those habitats that are fed with ground water or surface water. An initial assumption is that cold, glacial melt water influences the plant community composition (which influence the plant and animal diversity) and sedimentation rates of the salt marshes. We will be able account for abiotic differences among study locations (temperature, salinity, inundation, and sedimentation) but will depend on reference data sets for underlying local geology and proximity to human habitation which may also influence abiotic and biotic diversity and contribute and unknown amount of variation among sites.

Initial assumptions and levels of uncertainty with this research project will be outlined and discussed at the outset in the first quarterly meeting. Quarterly meeting updates will provide opportunities to share initial synthesis of data with full disclosure of process, uncertainties, and to get feedback on the utility of the data products and product formats. All findings from the front-end evaluation and needs assessment, yearly evaluations, and informal feedback will be shared with the CIU within a timely manner of each evaluation's analysis. Reviewed data will be synthesized on (at least) an annual basis and communicated through multiple outlets outlined below:

**Communication of Results:** Communication of project results will be far-reaching as outlined below. Each User group increases in breadth and number of participants involved/engaged/invited; also, the level of time commitment and expectations for the intended User group decreases accordingly.

**Core Intended Users -** Core Intended Users (identified in section 3), who have expressed commitment and full participation, will meet quarterly throughout the entire study. These mandatory meetings will provide opportunities for project updates, two-way communication on project results between the researchers and Users, science presentations to enhance general understanding of coastal processes and related project efforts, informal assessments of Collaborative Learning process, reports of previous evaluation results, and dissemination of educational products.

**Intended Users -** Intended Users are community members and organizational representatives that have expressed interest in this project and its results. Some intended Users, such as Bioblitz participants and Community Council members, will be involved for particular coordinated events, but will not have the same level of time commitment and expectations as a Core Intended User. Quarterly Community Council meetings will follow the Core Intended User quarterly meetings, providing an opportunity to share lessons-learned and synthesized feedback with the Community Council. Community Council meetings provide another venue to outreach educational products (such as

project one-pagers & Bay Science articles) and receive feedback on project results, process, and future efforts.

**Coastal community, science community, K-16 students & teachers -**This group involves community members that participate and support the wide-ranging Reserve activities. K-16 marine and estuarine lab & field classes, *Discovery Labs*, and CTP Workshops all provide an outlet to share project goals, methods, and results. Project one-pagers, science articles for local and state-wide newspapers, and figures created for this project can be disseminated appropriately throughout these educational opportunities. CTP workshops will highlight this project through project scientists' presentations which will be held throughout the term of this research project. *Discovery Labs*, such as "Earthquakes", "Coastal Processes in Kachemak Bay", and "Influences of Glaciers on Ecology", can highlight the goals, importance, and results of this study to local community members of all ages (see Timeline). KBNERR Educators will provide project highlights in their K-16 estuarine lectures and materials.

**The Public** - This group is all-ages and regional, state, national, and international in scope. Through summer *Discovery Labs* at the Alaska Islands and Ocean Visitor Center (which average 300 people/week of visitors from areas that range locally, nationally, and internationally) educational products will be highlighted. Media outlets such as two local, one regional, and one state newspaper and two National Public Radio and several commercial local radio stations will provide opportunities to disseminate project overviews, project benefits, opportunities for involvement, upcoming events, and project findings and results to a wide audience. The KBNERR (www.kbayrr.org) and KBNERR Community Council (kbaycouncil.wordpress.com) websites also provide an outlet to share project-related products.

**5. Integration of Project Participant Perspectives**

**Vetting critical aspects of the project –** Introduce, discuss, follow and uphold the 6 collaborative learning principles outlined in Christine Feurt's Guidebook:

1. Process: follow the cycle of experiential adult learning (assessment, design of an action strategy, implementation of strategy, evaluation of results, incorporation of results into design of the next action)
    a. At the first CIU quarterly meeting, the Collaborative Learning Process will be explained with an emphasis on the systems thinking and active, mutual learning approaches.
    b. The five fundamental principles of active learning (fairness, access, inclusion, transparency, and honesty) will be defined and a process to support these principles will be collectively determined (*fide* Walker et al. 2006).
2. Relationship: Stakeholders are considered equal partners in this effort and all participants respect backgrounds and perspectives that each brings to the collective.
    a. The KBNERR values and fosters respectful relationship-building and partnering in all of its efforts and this project is no exception.

    b. As mentioned above, all CIU and researchers will participate in the process of active learning which supports respectful communication and diverse perspectives.
3. Communication: is straightforward, honest, appropriate, respectful, and sincere. A process is agreed upon that fosters respectful dialogue and shared understandings.
    a. Sincere and respectful communication throughout this collaborative study will be upheld per the agreements made at the outset.
4. Inclusion: an effort is made to identify and include people who provide comprehensive perspectives on the research question or impact of findings AND are in the position to take actions that will move toward the desired outcomes.
    a. This research question proposed here was brought to the KBNERR by multiple community members.
    b. To shape this study, the KBNERR communicated with Users of wide-ranging perspectives, integrating multiple goals into this specific study to address the community concerns. Fortunately, these Users share a common desire for the information this study will provide and have already gone to great length to communicate support and continued commitment for this study's completion.
5. Participation: stakeholders are actively involved in the entire project process and are willing to commit to collective principles established at the outset.
    a. Collaborative Learning is a dynamic process and depends on constructive communication throughout by all CIU and researchers. Having the group clearly defining the expectations, goals, objectives, and process at the outset is essential for CIU empowerment and continued participation.
6. Facilitation: supportive facilitation that engages and catalyzes innovation and change.
    a. The Integration Lead will guide the collaborative process, ensuring that the process agreed upon by the group is followed and supported. Feedback and suggestions for improvement from group members on the collaborative process will be addressed and incorporated throughout the duration of this study.

By beginning with an open process where the CIU have the ability to help set the communication framework and a clearly stated process for vetting information, we believe there will be minimal disagreements or direct conflicts in this project. We have had a very engaged stakeholder group prior to and during the development of this proposal (evidenced by support from city and borough resolutions and Alaska State delegation for the project). However, we recognize that unforeseen issues can and do arise and the need for engaging in conflict resolution may occur. If such a situation becomes evident during the course of the project and cannot be resolved by the methods described above, we will bring in the additional support of an outside facilitator from Alaska SeaGrant or another qualified entity to aid in maintaining the legitimacy of the project.

## 6. Roles & Responsibilities

**Principal Investigator (PI):** Angela Doroff (KBNERR Research Coordinator) will have overall administrative responsibility for the project (timelines, personnel and budget management, data quality, and reporting), will assist with integration of the information to all Users, and lead on biological aspects of data collection and analyses. She has over 20yrs of experience with biological field studies and project management in Alaska. She will be responsible for the credibility and legitimacy of the project. She will attend quarterly meetings on the project in person and engage in two-way communication on the project idea, implementation, education and outreach, and transfer of results.
**Integration Lead (IL):** Megan Murphy (KBNERR Coastal Training Program Coordinator) will be responsible for the development and integration of a communication plan, vetting the project among the Users and researchers, integration of the research and education sectors roles, and will assist with data collection. She will facilitate quarterly meetings on the project and engage in two-way communication on the project idea, implementation, and transfer of results. She will organize and facilitate outreach and education on the project and will be responsible for evaluating the results of the outreach. She will have a shared responsibility for the credibility, relevancy, and legitimacy of the project. She has been coordinating outreach and education events in this region for the past six years and has excellent standing in the local community and throughout Southcentral Alaska.
**Other Investigators (OI):** All investigators (Steve Baird and Jeff Freymueller) will have supportive administrative responsibility for the project (timelines, budget management, data quality, and reporting), will assist with integration of the information to the Users, and will lead in data collection and analyses. Both will participate in quarterly meetings on the project in person or by teleconference and engage in two-way communication on the project idea, implementation, education and outreach, and transfer of results. Both have a shared responsibility for the credibility and legitimacy of the project. Dr. Jeffrey Freymueller is the lead author of the model on active deformation processes we will be updating for Kachemak Bay, and has published extensively on this topic in Alaska. He will be responsible for overseeing all deformation measurements (some will be carried out by other staff), data analysis and modeling of the GPS data, and assessment of land level vs. sea level rise. Steve Baird, Research Analyst, has extensive experience in salt marsh mapping and has conducted all of the KBNERR and lower Cook Inlet NERR Tier I sampling for emergent aquatic vegetation sampling and mapping, has conducted GIS analyses, and given multiple presentations on coastal erosion and glacial loss in this area. Steve will be responsible for field logistics, data collection, summary, analyses on salt marsh vegetation, establishment of vertical control on study sites, and report/manuscript writing.
**Intended Users:** Each Core Intended User (CIU) has agreed to active participation throughout the process during the course of the study. Active participation is defined as attending quarterly meetings on the project in person or via teleconference and engaging in two-way communication on the project idea, implementation, and transfer of results. All CIU have a responsibility to help provide legitimacy to the overall project through their direct participation.

All CIU will be able to demonstrate that they will use the information in some direct manner such as policy, local community decision making, planning or conservation of resources. The purpose of the quarterly meetings are to facilitate communication

between the CIU and the project researchers with the goal of understanding the strengths and limitations of the data collected in the study and the various needs of the User group. We will encourage the CIU group to be involved in a number of interim education and outreach events related to the topic of the study; annual workshop facilitated by the KBNERR Coastal Training Program which summarizes study results; and review of final products from the study.

**7. NERRS Involvement:** There is significant cross sector participation built into this proposal. The Research Coordinator is the PI, the Research Analyst is a co-PI, the entire Education staff are involved, the CTP coordinator is the Integration Lead, the Manager has facilitated the letters of commitment with the Intended User focus group, assisted in development and passage of city and borough resolutions to support the project, and will remain actively involved throughout the project, Administrative staff have facilitated the Community Council presentations on the Science Collaborative and will assist with all phases of the project with emphasis on facilitation of conducting future Community Council meetings. The Education staff will lead the Community Habitat Inventory (Bio-blitz) following protocols developed by the Research Team (involving Users, students (9-16), and community monitoring volunteers), develop *Discovery Labs* on the material for the public, and assist with data summaries.

National Estuarine Research Reserve System Science Collaborative
FY 2010 Funding Opportunity

# Timeline Form

**Proposal Title: Assessing Coastal Uplift and Habitat Changes in a Glacially Influenced Estuary System Located in Kachemak Bay, Alaska**

Please note: Q1 (Sept-Nov), Q2 (Dec-Feb), Q3(Mar-May) and Q4(June-Aug) refer to quarters of the year.

| **List Project Objectives, Products, Activities** | **Year 1 (9/10-9/11)** | | | | | **Year 2 (9/11-9/12)** | | | | | **Year 3 (9/12-9/13)** | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Q1 | Q2 | Q3 | Q4 | | Q1 | Q2 | Q3 | Q4 | | Q1 | Q2 | Q3 | Q4 |
| COR Stations, purchased and installed | X | X | | | | | | | | | | | | |
| Establishment of Salt marsh Sites | X | | | X | | | | | | | | | | |
| Monitoring Existing Benchmarks | X | | X | X | | X | | X | X | | X | | X | |
| Monitoring Salt Marsh Sites | X | | | X | | X | | | X | | X | | | X |
| Citizen Science Training | | | | X | | | | | X | | | | | |
| Citizen Science Monitoring Salt Marsh Sites | | | | X | | X | | | X | | X | | | |
| | | | | | | | | | | | | | | |
| Core Intended User Quartly Mtg | X | X | X | X | | X | X | X | X | | X | X | X | X |
| Community Council Quartly Mtg | X | X | X | X | | X | X | X | X | | X | X | X | X |
| CTP Workshop on Coastal Processes | | X | | | | | | | | | | | | |
| CTP Workshop Lessons Learned | | | | | | | | | | | | | | X |
| Discovery Lab “Coastal Processes” | | X | | | | | | | | | | | | |
| 1pg Overview of Project | X | | | | | X | | | | | X | | | |
| Newspaper article describing project | X | | | | | X | | | | | X | | | |
| Discovery Lab “Influences of Glaciers on Ecology” | | | | | | | X | | | | | | | |
| Discovery Lab “Earthquakes” | | | | | | | | | | | | X | | |
| | | | | | | | | | | | | | | |
| Annual Reporting to SC | | | | X | | | | | X | | | | | X |
| Annual Integration Lead/CTP Evaluation w/CIU | | | | X | | | | | X | | | | | X |
| Final Analyses and Reporting | | | | | | | | | | | | | | X |
| | | | | | | | | | | | | | | |

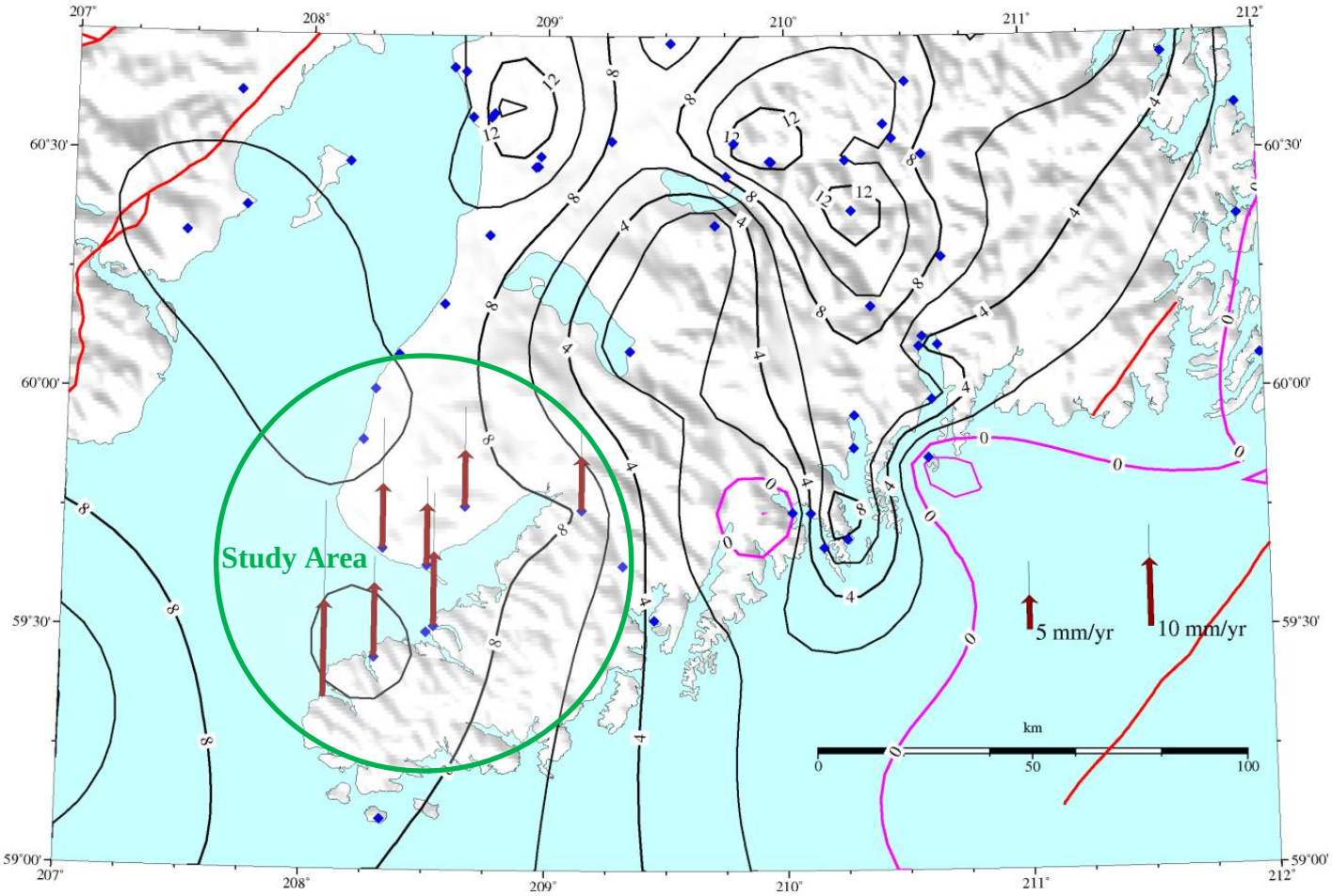


Figure 1. Detail of coastal deformation patterns (Freymueller *et al*. 2008) of Kachemak Bay and lower Cook Inlet. The red vectors show the actual observations with uncertainties (95% confidence) in the Kachemak Bay area. Contour interval is 2 mm/yr, pink contours are subsidence. The subsidence offshore is mainly tectonic. Blue diamonds are the sites used in deriving the contours, which weighted the data based on their uncertainties.